

**IN THE UNITED STATES DISTRICT COURT  
FOR THE NORTHERN DISTRICT OF OKLAHOMA**

STATE OF OKLAHOMA, *et al.*, )

*Plaintiffs,* )

v. )

Case No. 4:05-cv-00329-GKF-PJC

TYSON FOODS, INC., *et al.*, )

*Defendants.* )

**AFFIDAVIT OF VICTOR J. BIERMAN, JR., Ph.D**

I, Victor J. Bierman, Jr., having been duly sworn, under oath, state that the following facts are true and correct to the best of my knowledge, information, and belief:

1. This Affidavit is based upon my personal knowledge. I would and could competently testify to the matters stated in this Affidavit if called as a witness.

2. In this affidavit, I respond to the numerous new and often wrong statements made by Dr. Engel in his declaration attached as Exhibit C to Plaintiffs' Response to Defendants' Motion to Exclude Testimony of Dr. Engel (Dkt. No. 2157).

3. In Point 8 of his declaration, Dr. Engel states that "Engel et al. (2007) describes standard protocols appropriate for hydrologic/water quality modeling. This protocol was followed for the modeling documented in Engel's expert report (Engel's expert report Appendix D, State's response Exhibit B)." This is not correct. Supporting Statement 2j, Pages 21-25, in my expert report describes numerous specific examples of Dr. Engel's failure to follow his own published guidance.

4. In Point 9 of his declaration, Dr. Engel states that GLEAMS is a well established hydrologic/water quality model and that others have also used it for modeling sources of

nutrients in watersheds. The fact that GLEAMS is well established and has been used by other investigators at other locations does nothing to establish the accuracy or reliability of Dr. Engel's site-specific linked modeling system for the Illinois River Watershed ("IRW"). Furthermore, none of the published studies cited by Dr. Engel involves the same linked modeling system that he used for the IRW. Dr. Engel's linked modeling system includes GLEAMS, a routing model, the Shuffled Complex Evolution (SCE) algorithm for automated calibration of GLEAMS and the routing model, and his allocation spreadsheet for determining the relative contributions of phosphorus sources in the watershed. Dr. Engel's linked modeling system is specific for the IRW and its scientific credibility, accuracy and reliability should be judged based on the body of work that Dr. Engel has put forth to support the Plaintiffs' claims in this case, not on his citations of work by others.

5. In Point 10 of his declaration, Dr. Engel states that GLEAMS can be linked with other models in order to perform large scale watershed modeling. Though GLEAMS can be linked with other models, it does not follow that it can be applied in contravention to its inherent limitations. Shoemaker et al. (2005) specifically state three limitations for the use of the GLEAMS model: (1) Limited to an agricultural field of very small size; (2) Not suited for bigger watersheds; and (3) Not suited for urban land uses. Dr. Engel applied the GLEAMS model to the IRW in contravention to all three of these limitations. The IRW is not an agricultural field of a very small size, it has an area of approximately 1,000,000 acres, and it contains many urban land use areas. I have reviewed the papers identified by Dr. Engel in Points 9 and 10 of his Declaration where he makes the undisputed observation that other scientists have used GLEAMS as part of the modeling framework for evaluating the fate and transport of nutrients in other watersheds. However, none of those papers involve an application of GLEAMS to a watershed

of the size and complexity of the IRW configured in the flawed manner in which Dr. Engel configured his linked modeling system for this case. These papers simply do not confer legitimacy upon the conceptually flawed and poorly executed modeling framework used by Dr. Engel which extends far beyond the mere use of the GLEAMS model.

6. The land use areas in the IRW to which Dr. Engel applied his GLEAMS model are too large to accurately represent nonpoint source runoff from local sources. To run his GLEAMS model, Dr. Engel divided the IRW into 50 hydrologic response units (HRU), each composing a combination of land use areas, soil types, rain gauge areas, and loading zones, and then individually applied GLEAMS to each HRU. These large areas do not accurately represent the hydrology, soils and topography of the fields from which the phosphorus loads actually originate. Knisel & Nicks (1980) provided the following guidance on appropriate field size on Page 2 in Volume I of the Model Documentation for CREAMS: A Field Scale Model for Chemicals, Runoff, and Erosion from Agricultural Management Systems:

*What size is a field? The physical size of farm fields varies from a few acres in ridge and valley provinces to a few tens of acres in the Corn Belt to a few hundreds of acres in the Wheat Belt and western rangelands.*

CREAMS is the predecessor model to GLEAMS and is based on the same science. Thirty nine (39) of Dr. Engel's 50 HRUs (78%) were larger than 1,000 acres, including one that was 99,148 acres, and thus exceeded the guidance on field size by greater than an order of magnitude.

7. The use of the LOADEST model by the USGS to compute phosphorus loads at two gages in the IRW used by Dr. Engel does not in any way confer legitimacy on Dr. Engel's routing model or its application to predict phosphorus loads to Lake Tenkiller. In Point 27 of his declaration, Dr. Engel states that, "The form of the equations used for the phosphorus routing are not unique, rather they are of the form of the equations in LOADEST (Runkel et al. 2004)." The



equations in Dr. Engel's routing model may be of similar form to those in LOADEST, but these two models are fundamentally different. LOADEST is an empirical model but it is not a routing model. It computes phosphorus loads at a single point in space using measurements for flow and phosphorus concentration taken at that point. It does not deliver loads from one location to another. Dr. Engel's routing model, however, relates phosphorus loads at edge-of-field locations throughout the IRW predicted by his GLEAMS model (plus wastewater treatment plant loads) to his observed phosphorus loads to Lake Tenkiller at the three USGS gages on the Illinois River near Tahlequah, Baron Fork at Eldon and Caney Creek near Barber.

8. In Point 12 of his declaration, Dr. Engel states that hydrologic/water quality models are routinely used to identify sources or allocate environmental contaminants to specific sources. In Point 13 he goes on to state that allocation of the magnitude of pollutant proportions to sources is done using various approaches including mass balance, pollutant coefficients, regression analysis and hydrologic/water quality models. In Point 32 he goes on to state further that allocation of pollutants to their sources is not novel and has been done commonly and routinely for analysis such as TMDL development. The fact that various types of models and approaches are routinely used to identify sources and/or allocate pollutants does nothing to establish the accuracy or reliability of the site-specific methods that Dr. Engel used to determine the relative contribution of sources, including poultry litter application, to the phosphorus loads to Lake Tenkiller in this case. The methods that Dr. Engel used to make this determination for the IRW depend not only on his allocation methods themselves, but on his entire linked modeling system for the IRW. None of the published studies cited by Dr. Engel involves the same linked modeling system he used for the IRW. Dr. Engel's linked modeling system includes GLEAMS, a routing model, the SCE algorithm for automated calibration of GLEAMS and the routing model, and his allocation

spreadsheet. Dr. Engel's allocation methods depend on results from all of the components in his linked modeling system. The scientific credibility, accuracy and reliability of Dr. Engel's methods and results for phosphorus allocations to sources in IRW should be judged based on the body of work he has put forth to support the Plaintiffs' claims in this case, not on his citations of work by others.

9. In Point 18 of his declaration, Dr. Engel gives the following reason for not including stream bank erosion in his modeling and source allocation analysis: "Stream bank erosion is not a source of phosphorus being imported into the IRW watershed which would in turn, increase phosphorus loads and concentrations above naturally occurring background levels." Stream bank erosion is an important source of phosphorus even in the absence of poultry litter application because naturally-occurring phosphorus binds tightly to soil and sediment particles. For example, phosphorus loads from stream bank erosion are included explicitly in the eutrophication model for Chesapeake Bay (Cerco & Noel, 2004). Conceptually, Dr. Engel encased the entire IRW, including all of the air, land and water compartments, in a "bubble" and considered only the phosphorus movements into and out of this "bubble" as having water quality significance. These phosphorus movements are irrelevant to water quality impacts in the IRW. The only phosphorus movements that are relevant are those that occur inside this "bubble" from land to water or from atmosphere to water. Stream bank erosion is one of these movements because it represents delivery of solids from the watershed within the IRW to streams and rivers or to Lake Tenkiller.

10. Dr. Engel incorrectly applied GLEAMS to all urban lands in the IRW and represented them as agricultural fields for alfalfa-hay in his urban plant nutrient input file. GLEAMS is an agricultural field-scale model that was not designed to represent urban land use (GLEAMS gives

the user an option to model a field either as an agricultural field or as a forest area, but not an urban area (Knisel & Davis, 2000)). Dr. Engel set the crop type in this urban plant nutrient input file as alfalfa-hay (ICROP = 2) and used all of the default nutrient input parameters in the GLEAMS user manual for this crop type. Contrary to his representation in Point 24 of his Declaration, Dr. Engel's urban plant nutrient input file was never modified to represent urban land use.

11. The assertion that GLEAMS has been widely calibrated and validated with edge-of-field data by other investigators at other locations does nothing to establish the accuracy or reliability of Dr. Engel's GLEAMS results for the IRW. In Point 29 of his declaration, Dr. Engel states that, "It was unnecessary to compare the GLEAMS model to edge-of-field data within the IRW" because according to scientific literature, the GLEAMS model "has been widely calibrated and validated with edge-of-field data." A site-specific application of GLEAMS, however, requires site-specific calibration. Dr. Engel should have followed the actual approach used in the scientific literature and compared his GLEAMS model to edge-of-field data in the IRW, especially considering that Plaintiffs themselves collected 146 measurements for phosphorus and 58 measurements for total solids (sediment) at edge-of-field locations in the IRW.

12. Dr. Engel should have calibrated his modeling system for sediment. In Point 30 of his declaration, Dr. Engel cites several papers and a USGS report for the proposition that it was not necessary to calibrate his modeling system for sediment. Contrary to his assertion, one paper he cites (Gassman et al. 2007) actually contains results from 11 different studies (Table 3) in which SWAT was calibrated for both solids (sediment) and total phosphorus, and only one study in which it was calibrated only for total phosphorus. Furthermore, Dr. Engel ignores his own published paper (Engel et al. 2007) on hydrologic/water quality models in which he stated that,



“The model is typically calibrated first to obtain acceptable performance in the hydrologic components, then for sediment, and finally for nutrients, pesticides, bacteria or other constituents.”

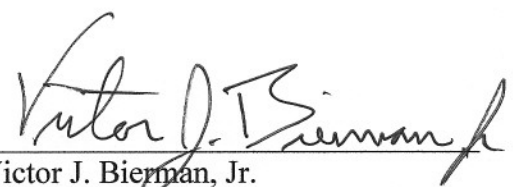
13. The methods that Dr. Engel used to develop his phosphorus allocations in the IRW are conceptually flawed, undocumented, contain numerous errors and inconsistencies, and are not reliable to a reasonable degree of scientific certainty. *See* Bierman Report, Supporting Statement 3b, Pages 31-34. In Point 33 of his declaration, Dr. Engel states that he used phosphorus loads from waste water treatment plants (WWTPs) and outputs from his GLEAMS model to allocate phosphorus loads in the IRW between point and nonpoint sources, and to identify the nonpoint source phosphorus loads attributable to each source, including poultry litter application. The results are reported in Tables 10.14 and 10.15 of his expert report and in Opinion 8 which states that, “Poultry waste land application in the IRW is a substantial contributor (45% between 1998 and 2006 and 59% between 2003 and 2006) to P loads to Lake Tenkiller, representing the largest P source.” As part of my investigation, I conducted an analysis with Dr. Engel’s own allocation method showing that his results were very sensitive to his assumptions about cattle contributions, and that his allocation method could even produce negative percentages for contributions of poultry litter to phosphorus loads to Lake Tenkiller. I have reviewed the papers identified by Dr. Engel in Points 12, 13 and 32 of his Declaration where he discusses the unremarkable fact that other scientists have used various methods to allocation pollutant loads to sources in connection with hydrologic modeling work. None of those papers disclose, discuss or attempt to validate the allocation methods developed and implemented by Dr. Engel in this case using his same linked modeling system.

14. In Point 40 of his Declaration, Dr. Engel is critical of the sensitivity analysis I conducted with his routing model using different watershed loadings and even random inputs. He suggests that this sensitivity analysis does not invalidate his routing model for the IRW because “the inputs used by . . . [me] do not represent the conditions in the watershed when the actual phosphorus loads were observed.” Dr. Engel’s point is misplaced and the tests I conducted do demonstrate the lack of utility and reliability in his routing model. Nevertheless, what Dr. Engel ignores is that he himself unwittingly conducted a sensitivity analysis with his own complete linked modeling system for the IRW using varying input data to represent actual conditions. Dr. Engel’s own work demonstrates that his linked modeling system is flawed and that its results are not accurate or reliable. In Point 41 of his declaration, Dr. Engel describes a mistake in the GLEAMS model code used for his predicted phosphorus loads for Tahlequah, Baron Fork near Eldon, and Caney Creek in his original expert report. He states that the mistake and how it occurred are explained in detail in his errata, and that the majority of the tables and figures in Chapter 10 of his original expert report required correction. His declaration admits, “The mistake was of a nature that it did not result in significant changes to figures and tables in Chapter 10 of my report and therefore the substance of my major opinions was unchanged.” The details of this mistake reveal a major flaw in Dr. Engel’s model. As Dr. Engel explained on Pages 32-34 of his deposition, the GLEAMS model results in his original expert report represent nonpoint source runoff loads from only 27 of his 50 total HRUs in the IRW. That is, due to the mistake in his GLEAMS model code, his other 23 HRUs were “left out.” The 27 HRUs that were included represent only 52% of the pasture land area and only 46% of the total land area in his 50 HRUs. The corrected results in Dr. Engel’s errata represent nonpoint source runoff loads from all 50 of his HRUs. What this means is that Dr. Engel’s linked modeling system for the



IRW gives the same answers for predicted phosphorus loads to Lake Tenkiller for half of his pasture land area as it does for all of his pasture land area. This defies logic and common sense. This result is demonstrable and stands on its own. It is fully contained within Dr. Engel's own body of work and does not depend on any analysis or tests I conducted. This result confirms my opinions that Dr. Engel's modeling framework for the IRW is conceptually flawed and that its results are not accurate or reliable.

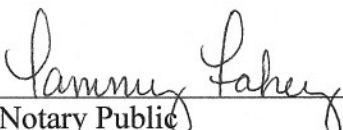
FURTHER Affiant Sayeth Not.

  
Victor J. Bierman, Jr.

State of NC )  
County of Guilford ) ss

SUBSCRIBED AND SWORN to before me, a notary public, on this 19<sup>th</sup> day of

June, 2009.

  
Notary Public

My Commission Expires:

12.14.11.

